

Comparing the observed properties of the GRBs detected by  
the Fermi and Swift satellitesL. G. BALÁZS<sup>1,3</sup>; I. HORVÁTH<sup>2</sup>; Z. BAGOLY<sup>2,3</sup> AND J. KÓBORI<sup>3</sup><sup>1</sup>*MTA CSFK Konkoly Observatory, Budapest, Hungary;* <sup>2</sup>*National University of  
Public Service, Budapest, Hungary;* <sup>3</sup>*Eötvös University, Budapest, Hungary*

We studied the distribution of the GRBs, observed by the Fermi satellite, in the multidimensional parameter space consisting of the duration, Fluence, Peak flux and Peak energy (if it was available). About 10% of the Fermi bursts was observed also by the Swift satellite. We did not find significant differences between the Peak flux and Peak energy of GRBs observed and not observed also by the Swift satellite. In contrast, those GRBs detected also by the Swift satellite had significantly greater Fluence and duration. We did a similar study for the GRBs detected by the Swift satellite. About 30% percent of these bursts was also measured by the Fermi satellite. We found a significant difference in the Fluence, Peak flux and Photon index but none in duration. These differences may be accounted for the different construction and observing strategy of the Fermi and Swift satellites.

PRESENTED AT

Huntsville Gamma Ray Burst Symposium, GRB 2013,  
Nashville, Tennessee, USA

# 1 Introduction

The Swift (launched in 2004) and the Fermi (launched in 2008) satellites have revolutionized the high energy astronomy in different manners: Swift is capable to detect GRBs and measure their gamma, X-ray and optical properties, along with their celestial position of high accuracy on the cost of a limited FoV and the nominal  $\gamma$  spectral range of the BAT instrument is 15-150 keV [1]. In contrast, the Fermi satellite has the GBM telescope covering the whole sky simultaneously, except that part eclipsed by the Earth, energy response up to 1 MeV with the NaI detectors (30 MeV with BGO detectors) [2] but on the cost of a limited accuracy of getting spatial position of the GRBs. A very attractive feature of the satellite is the LAT [3] capable to localize and detect photons above the energy of 10 MeV. Although, the energy range of the Swift and Fermi GBM sensitivity has a significant overlap, the differences in detection strategy and construction may result deviations between the GRB populations observed by these two experiments. Therefore, it is an interesting issue to make comparison between GRBs detected by both satellites and those registered only one of these two instruments. Due to the different geometry of the orbits of the two satellites it could well happen that some of the bursts were in the FoV at only one of them. In the following we shortly address this issue. We used the data in the Fermi GBM Catalogue [4] and Swift GRB Table [5].

# 2 Coincidence between Fermi and Swift detections

From the very beginning of the Fermi experiment in 2008 the GBM detected 1070 bursts until mid of February, 2013, starting the necessary statistical computations. In the same period Swift recorded 409 GRB events. Taking the Fermi bursts we searched for the nearest Swift burst in time and position and computed the differences. Unfortunately, for the majority of bursts detected by the GBM the accuracy of the celestial position was in the order of a degree which is too coarse for getting a reliable spatial coincidence. We display the scatter plot between the time and spatial difference to the nearest Swift burst in Figure 1. It is obvious already at the first glance of this Figure that the points forms two completely separated clusters. It is also evident from this Figure that points seem to coincide with Swift detection time may deviate considerably in the Fermi position. A good example for this is the group of points between the two major concentrations. We considered those bursts to be detected by both satellites which fulfilled the  $dtime < 10^{-3}$  day and  $distance < 10^{-3}$  radian conditions. In this way out of the 1070 burst detected by Fermi only 115 could be considered as also detected by the Swift satellite.

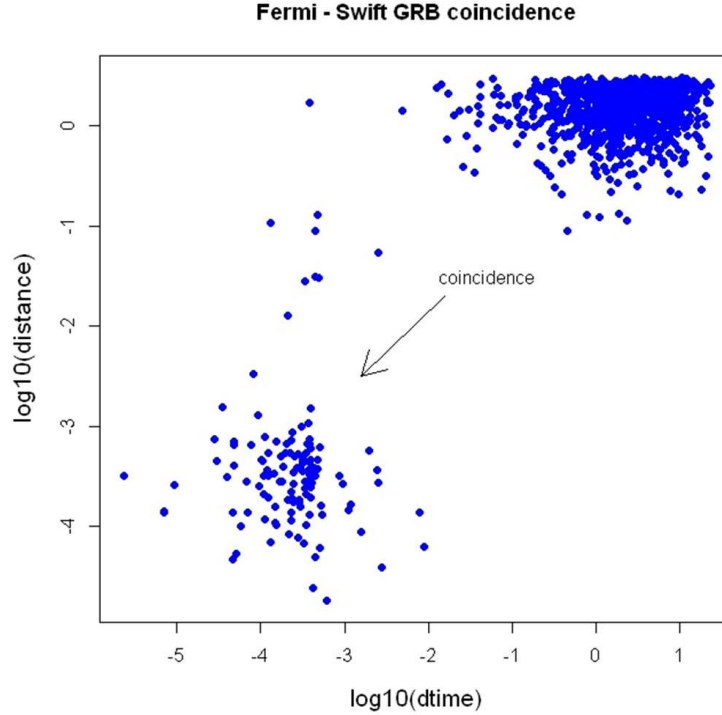


Figure 1: Coincidence between the Fermi and Swift detections. The point cluster at the left lower side of the scatter plot is considered as bursts jointly detected by the Fermi and Swift satellite

### 3 Fermi GRBs detected/non detected by the Swift

Since the two satellites have different spectral responses and sensitivities it is an appropriate question whether there is some systematic difference between bursts detected only by the Fermi or jointly by the Swift satellite. We compared the duration, fluence, peak flux and spectral peak energy by means of Kolmogorov-Smirnov (KS) tests. In Table 1 bold face means significant differences.

Table shows that no difference can be detected in the Peak intensity and the spectral Peak energy. The Peak intensity is the primary physical quantity responsible for the detection. If it does not exceed the noise level significantly, the burst is not detected. Since there is no significant difference between the jointly and only by the Fermi detected bursts in the Peak flux, the low fraction of the joint detections may be explained by the much greater FoV of Fermi. The significant differences in  $t_{90}$  and Fluence may originate from higher sensitivity of Fermi for GRBs of short duration.

	Fluence	t90	P1024	Epeak
Most Extr. Diff. Absolute	.194	.145	.107	.096
Positive	.194	.145	.107	.051
Negative	-.003	-.022	-.006	-.096
Kolmogorov-Smirnov Z	2.018	1.511	1.111	.688
Asymp. Sig. (2-tailed)	<b>.001</b>	<b>.021</b>	.169	.730

Table 1: KS test statistics of Fermi GRBs detected/non detected by the Swift. Bold face means significant difference.

	t90	Fluence	Peak	Pind
Most Extr. Diff. Absolute	.085	.279	.332	.170
Positive	.078	.279	.332	.022
Negative	-.085	-.013	-.005	-.170
Kolmogorov-Smirnov Z	.752	2.521	2.976	1.540
Asymp. Sig. (2-tailed)	.624	<b>.001</b> >	<b>.001</b> >	<b>.017</b>

Table 2: KS test statistics of Swift GRBs detected/non detected by Fermi. Bold face means significant difference.

## 4 Swift GRBs detected/non detected by Fermi

In the same period in which we considered the Fermi GRBs Swift recorded 409 bursts. The Swift is working in observatory mode, consequently, its FoV is significantly smaller. On the contrary, it has higher sensitivity. Due to its construction Swift BAT has smaller beam size than the Fermi GBM. Assuming the same background level at both satellites the smaller beam size results in smaller noise contribution to the burst event to be observed. For making a comparison between GRBs detected jointly by the BAT and GBM and by the BAT alone we selected Fluence, t90, Peak flux and Photon index. We compared these variables between the non detected and jointly detected groups by performing KS tests. Table 2 summarizes the results.

The Table shows that except the t90 duration there are significant differences between the Fluence, Peak flux and Photon index. The strongest difference appears in the Peak flux. The reason for this difference may be accounted for the higher sensitivity of the BAT instrument. To demonstrate this difference we displayed the cumulative distribution of the Peak flux in the non detected and jointly detected group in Fig. 2.

Figure 2 demonstrates convincingly that about 30% of the GRBs, detected by the BAT only, have fainter Peak flux than those recorded also by the GBM. On the other hand, it means that 70% of the BAT detected GRBs are above the threshold

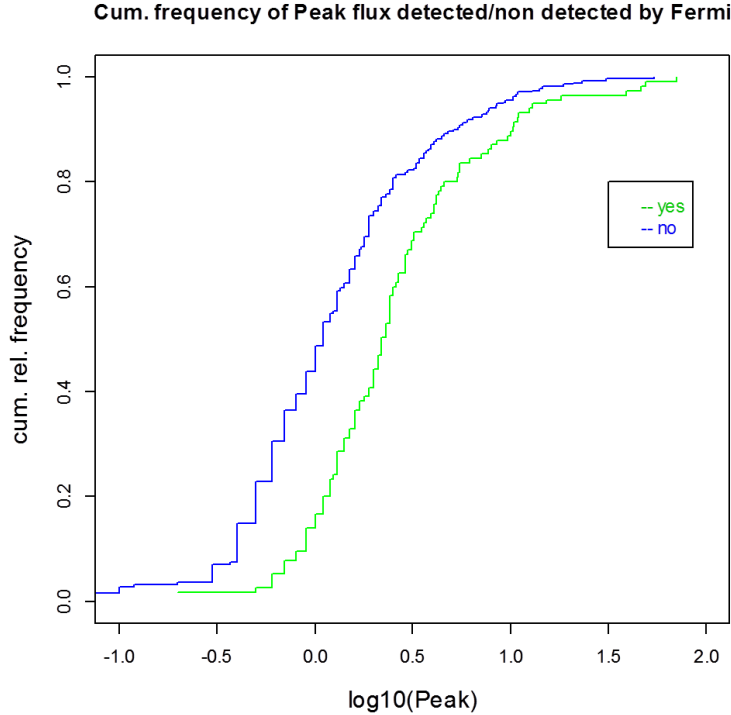


Figure 2: Comparison of the cumulative distribution of Swift GRB’s peak fluxes detected/non-detected (green/blue) by the Fermi satellite. KS test indicates a significant difference at the  $> 99.9\%$  level.

of GBM. An obvious reason of this contradiction is the different orbital position of the two satellites, and consequently the different part of the sky covered by the Earth (unfortunately, the detailed study of this effect is already beyond the scope of this work).

## 5 Summary and Conclusions

We compared the GRB detections of the Swift and the Fermi satellites. We studied the period from the beginning of the Fermi mission until middle of February 2013. In this period Fermi registered 1070 burst while Swift recorded 409 events. We considered the GRBs as jointly observed by both satellites if the time and positional difference was less than  $10^{-3}$  day and  $10^{-3}$  radian, respectively. We obtained 115 bursts fulfilling these criteria. Using Kolmogorov-Smirnov (KS) tests we compared the distributions of the durations, Fluence, Peak flux and  $E_{\text{peak}}$  of the bursts which were jointly detected by both satellites and by the Fermi alone. We did not get

significant difference between the two category of the bursts in the Peak flux and Epeak distributions. On the other hand, a significant difference can be obtained in the Fluence and duration. This effect may be accounted for the higher sensitivity of Fermi to the bursts of short duration ( $t_{90} < 2\text{s}$ ).

A similar comparison of the duration, Fluence, Peak flux and Photon index of bursts of jointly detected and by the Swift alone resulted in significant differences utilizing KS tests, except the duration. The most significant difference was obtained in the Peak flux. Comparing the cumulative distribution of the Peak flux of the two categories (jointly detected and by the Swift alone) demonstrated that about 30% of the Swift GRBs is below the detection limit of Fermi. Since 70% of the bursts detected by the Swift alone is in the sensitivity range of Fermi the non detection may caused by the differences in the orbital position at observing a given burst.

Summarizing all these things we concluded that the differences in detections of the Fermi and Swift satellites may be accounted for the different construction and detection strategy, along with the different orbital positions at a particular burst event.

## ACKNOWLEDGEMENTS

This research was supported by OTKA grant K77795, by OTKA/NKTH A08-77719 and A08-77815 grants (Z.B.).

## References

- [1] Swift BAT, [http://heasarc.nasa.gov/docs/swift/about\\_swift/Sci\\_Fact\\_Sheet.pdf](http://heasarc.nasa.gov/docs/swift/about_swift/Sci_Fact_Sheet.pdf)
- [2] Fermi GBM, <http://gammaray.msfc.nasa.gov/gbm/instrument/description/>
- [3] Fermi LAT, <http://heseweb.nrl.navy.mil/glast/>
- [4] Fermi GBM catalogue, <http://heasarc.gsfc.nasa.gov/W3Browse/fermi/fermigbrst.html>
- [5] Swift GRB Table, [http://swift.gsfc.nasa.gov/docs/swift/archive/grb\\_table/](http://swift.gsfc.nasa.gov/docs/swift/archive/grb_table/)